Scientific Assessment and Evaluation of ASL Developed Moist Atmosphere Models for Low Stratus Subclouds.

(2)

Contract No. DAJA45 - 87 - M - 0333

Prof. Dr. Gottfried Hänel
Institut für Meteorologie und Geophysik
Feldbergstrasse 47
6000 Frankfurt am Main
F. R. Germany

August 28, 1987

Final Technical Report

on my discussions with ASL and PSL scientists during Aug. 12 until Aug. 25, 1987, in the Physical Sciences Laboratory (PSL), Las Cruces, New Mexico

My discussion partners were mainly Dr. Henry Rachele (ASL), Dr. Neal Kilmer (PSL), Mr. J. Lindberg (ASL), Dr. J. Gillespie (ASL), and Dr. R. Loveland (PSL). The discussions were related to the three main topics to be described subsequently:

A. Theory by Henry Rachele and Neal Kilmer, sensitivity studies, and comparison between models and presently available field data

The following topics were discussed:

1. Improvement of the formulations for the moist potential temperature and of the water budget equation to be used in "A similarity model for moist haze".
2. Introduction of non-equilibrium growth of particles to cloud droplets into the model mentioned above and into the "Moist haze microphysics profile model".
3. Simplification of the final particle growth model to allow faster calculations.

4. Use of measured particle growth data for model calculations and derivation of particle growth data from the measured chemical composition of the particles.

5. Introduction of particle concentration profiles into both models.

6. We agreed on the following strategy for futural work: Both models should be brought into final form at first. Secondly sensitivity studies about the aerosol property influences on the extinction and mass loading profiles and more comparisons of the models with available experimental results should be performed. These studies will give more informations about the minimum accuracies of the aerosol properties to be measured during field experiments.

B. Design of field experiments.

To ultimately proof both models additional field experiments are required. In each case the vertical profiles of horizontal wind, temperature, and humidity have to be measured together with those of the mass loading and/or extinction. The working group has discussed extensively the accuracy requirements for the profiles of temperature and relative humidity. The temperature must be known within 0.01 K. The error of the relative humidity should not exceed 0.1 to 0.3 percent. The measurements should be taken at temperatures slightly larger than 0 C to obtain optimum results. Near the ground (at the reference height) the chemical composition and the size distribution of the particles should be measured together with the temperature and the relative humidity with the highest accuracies which can be achieved. Field experiments can be realized on and after Nov. 1988.

C. Refractive index mixture rules.

To be able to calculate realistic vertical extinction profiles the complex refractive indices of the particles must be known at all heights. For this a refractive index mixture rule has to be used. Dr. Gillespie and I have discussed the physics, the applicability, and the

accuracies of presently available mixture rules. We concluded that the application of presently available mixture rules to wet aerosol particles and cloud droplets should be reinvestigated using also the recent experimental data from the literature.

Accession For	
NTIS GRA&I	☑
DTIC TAB	☐
Unannounced	☐
Justification	
By per letter	
Distribution/	
Availability Codes	
Dist	Avail and/or Special
A-1	

Prof. Dr. Gottfried Hänel
Institut für Meteorologie und Geophysik
Feldbergstraße 47
6000 Frankfurt am Main
F. R. Germany

Report on the papers "Moist haze microphysics profile model" (Paper I) and "A similarity model for moist haze" (Paper II) by Henry Rachele and Neal Kilmer and on the discussion I had with Mr. James Lindberg from White Sands Missile Range during June 18 and 19 in Frankfurt:

The problem is to describe the thermodynamics and haze microphysics of the subcloud layer. This is extremely difficult if the cloud is low and the lower boundary of the subcloud layer is the ground like in the present case. In such a case an adequate description of the turbulent processes in the subcloud layer is necessary to get reliable results. The related problems are difficult because the condensation processes have a considerable influence on turbulence. Unfortunately the solution of this problem is not found in the literature. The work of the authors is important for the design and operation of electro-optical systems.

Both papers are valued as very good first approximations to an extremely complicated problem. After having read the papers I sent some comments to the authors. Their replies and changes of the model have been discussed during and reviewed again after the visit of Mr. Lindberg in Frankfurt.

In summary the present model theory is a considerable improvement of the theory in the papers I and II mentioned above. There have been made some minor changes which need not to be mentioned. The most important improvements are the consideration of condensational and of ground roughness effects on turbulence.

During his visit in Frankfurt I have discussed with Mr. Lindberg the present state of modelling, further improvement of the model theory, and experimental verification of the model.

Suggestions concerning improvement of theory:

1. At relative humidities larger than about 98 percent equilibrium thermodynamics becomes inapplicable to medium size and large particles. Because of the slowness of water vapor diffusion these particles will remain smaller than in equilibrium (G. Hänel, Contrib. Atmos. Phys. **60**, to be pub. 1987). The results by W. Seidl and G. Hänel ("Einflüsse von Aerosoleigenschaften und meteorologischen Parametern auf die Entstehung von Nebel und Wolken", Abschlussbericht, Bundesminister für Forschung und Technologie, Forschungsvorhaben 423-4007-0704570 8, 1986) have shown that the model could be improved implementing non-equilibrium thermodynamics approximately.

2. The ground is a sink for particles. Thus it should be considered that the particle concentration increases with height (compare D. J. Carruthers and T. W. Choularton (1986), Quart. J. R. Met. Soc. **112**, 113-129).

3. Improved aerosol models should be used for the computations. Details concerning this will be discussed during my visit in White Sands Missile Range.

Experimental verification of the model:

Comparison of measured and computed liquid water profiles in the subcloud layer yields that there should be an agreement between present theory and reality within a factor of about 3. Considering the errors of measurement and the above mentioned suggestions this agreement is valued to be very good and promising. Further steps of improvement of the model and its final version should be checked by well designed experiments. Since the model has to be verified in many details the related experiments will be not cheap. To reduce costs to a minimum the following strategy is suggested:

1. Make sensitivity studies with the present model to determine the minimum experimental information necessary and to get an insight how accurate this information has to be.

2. Compare the present model with the presently available incomplete data sets to learn which features have to be improved and what the approximate magnitudes of the necessary improvements are.

3. Improve the model and compare again with the presently available data.

4. If these comparisons yield satisfactory results make sensitivity studies with the improved model and design the verification measurements.

This strategy and related details should be discussed during my visit in New Mexico this August.